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VIRUSES IN WASTE, RENOVATED, AND OTHER WATERS

Editor: Gerald Berg, Ph. D.
Editorial Assistant: F. Dianne White

1977

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AUTHOR AND SUBJECT INDEXES

VIRUSES IN WASTE, RENOVATED, AND OTHER WATERS now contains an *Author Index* and a *Subject Index*. Both listings may be found at the end of this volume. The Greek letters that appear above each abstract are the coding for the *Subject Index*. An explanation for their meanings is given on the first page of that index.

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1977

VIRUSES IN WASTE, RENOVATED, AND OTHER WATERS

μ

Akin, E. W., Jakubowski, W. *Viruses in Finished Water: The Occoquan Experience.* **In "Proceedings AWWA Water Quality Technology Conference," San Diego, California, December 1976. American Water Works Association, Denver, Colorado** (1977), 1-10.

During the summer of 1975, poliovirus 1 was recovered from three finished water sites of the Occoquan Reservoir System (Virginia) by a United States Environmental Protection Agency (USEPA) contractor. The authors of this paper argue that the viruses were contaminants because coliform and viral counts at the System's water intakes were not high, because free chlorine residuals of at least 1 to 2 mg/liter had been maintained in the waters for many hours, and because a USEPA laboratory had not recovered viruses from finished waters in a plant where it had recovered 85 viruses from 100 gallons (378 liters) of intake water.

$\pi\ \delta$

Appleton, H., Pereira, M. S. (1977). *A Possible Virus Aetiology in Outbreaks of Food-Poisoning From Cockles.* **LANCET, (8015)**:780-1.

Large numbers of small, round, virus-like particles were detected in the feces of three patients with gastroenteritis suffered in an outbreak associated with the consumption of cockles. The virus-like particles were similar in size, morphology, and density to particles seen in outbreaks of winter vomiting (WV) and non-bacterial gastroenteritis (NBG), although the particles detected in the cockles outbreak appeared to be serologically unrelated to the particles detected in the WV and NBG outbreaks.

No bacterial pathogens were recovered from the feces of patients or from cockles.

$\chi\ \iota\ \mu$

Bagdasaryan, G. A., Nedachin, A. Y., Doskina, T. V. (1977). *The Effect of Chemicals on Some Microbial Self Purification Processes in Bodies of Water.* **GIG SANIT, 0(2)**:104-6. **Russian.**

Enteric viruses were unaffected in a stream polluted by petroleum wastes and by anion-active SPAV. The enteric viruses were recovered in equal numbers where the domestic and industrial pollutants mixed and at points 1, 2, and 3 days flow downstream. Coliphages were also unaffected by the industrial

pollutants. Intestinal bacilli, however, were reduced in numbers by more than 99% after three days of flow.

Bdellovibrio bacteriovorus, present in the stream below the domestic discharge, was undetectable in the domestic waste-industrial waste mixing zone but was recovered 1, 2, and 3 days flow downstream in numbers equal to those in the stream where only the domestic waste was present.

Coliphages appeared to be better indicators of enteric viruses than the bacterial indicators in waters contaminated with the industrial pollutants.

ν β τ

Balluz, S. A., Jones, H. H., Butler, M. (1977). *The Persistence of Poliovirus in Activated Sludge Treatment.* **J HYG, 78(2)**:165-73.

About 85% of the poliovirus 1 seeded in a single dose or seeded continuously into a model activated sludge treatment plant was associated with the suspended solids of the sludge. Only small numbers of viruses were recovered from the effluent.

The efficiency of the plant for removing the poliovirus was closely related to the plant's capability for removing suspended solids.

γ

Bates, R. C., Shaffer, P. T. B., Sutherland, S. M. (1977). *Development of Poliovirus Having Increased Resistance to Chlorine Inactivation.* **APPL ENVIRON MICROBIOL, 34 (6)**:849-53.

Poliovirus 1 (LSc) virions that survived chlorination became increasingly resistant to chlorine during repeated cycles of exposure to the halogen.

α β

Baylor, E. R., Baylor, M. B., Blanchard, D. C., Syzdek, L. D., Appel, C. (1977). *Virus Transfer from Surf to Wind.* **SCIENCE, 198(4317)**:575-80.

Bubbles in the sea surf adsorbed and carried seeded coliphages T2 and T4 to the surface where they were propelled into the air on tiny jets of seawater when the bubble burst. The ejected jets became tiny drops of aerosol.

The bubbles adsorption and phage concentration in the surf is analagous to industrial bubble levitation processes that concentrate metallic ores, enzymes, and finely divided organic crystals. Bubble levitation of phages seeded into the surf produced 200 times more phages/ml in the aerosol than there were in the surf.

Some aerosol drops created by the surf were carried by the wind and fell out on the beach. The frequency of phage-bearing drops, as measured by the number of plaques that developed on seeded plates exposed on the beach, decreased exponentially with the distance downwind from the surf.

α β

Baylor, E. R., Peters, V., Baylor, M. B. (1977). *Water-to-Air Transfer of Virus.* **SCIENCE, 197(4305)**:763-4.

Bubbles rising through suspensions of coliphages T2 and T4 and of *Escherichia coli* adsorbed and ejected these particles in droplets that formed when the bubbles burst.

Electron microscopy demonstrated that the concentration of the viruses in ejected droplets exceeded the concentration in the suspension by 50-fold.

Similar results were obtained for *E. coli*.

Many of the adsorbed particles were viable.

μ

Bellelli, E. Bracchi, U., Sansebastiano, G. (1976). *Research on the Water Quality of the Taro River in the Section Between Fornovo and the River Mouth.* **ATENEO PARMENSE, 12(3)**:213-38. **Italian.**

During a study on the water quality of the Taro River from December 1972 to November 1973, a reovirus 1 was recovered in December 1972 and a poliovirus 1 was recovered in February 1973. *Salmonella* were recovered at the same time.

ρ ν

Bertucci, J. J., Lue-Hing, C., Zenz, D., Sedita, S. J. (1977). *Inactivation of Viruses During Anaerobic Sludge Digestion.* **J WATER POLLUT CONTRL FED, 49(7)**:1642-51.

Coliphage MS2, poliovirus 1, coxsackievirus A9, coxsackievirus B4, and echovirus 11 seeded into sludge digesting anaerobically at 35 C were inactivated at average rates of 89%, 95%, 98%, 91%, and 54%/24 hours, respectively.

λ

Beytout, D., Charrier, F., Laveran, H., Monghal, M. (1977). *Detection of Small Amounts of Viruses (Enteroviruses) in Drinking Water.* **ANN MICROBIOL, 128(2)**:255-62. **French**

From 23% to 80% of 60 PFU of enteroviruses seeded into 30 liters of water were recovered by adsorption of the viruses onto cellulose nitrate filters and subsequent elution therefrom.

Only 10% of a seeded adenovirus was recovered with this technic.

χ

Blawat, F., Potajallo, U., Dabrowski, J., Towianska, A., Jarnuszkiewicz, I. (1976). *Survival of Some Viruses in the Sea-Water Samples Collected from the Gulf of Gdansk. Preliminary Studies.* **BULL INST MAR TROP MED GDYNIA, 27(3-4)**:331-9.

In laboratory studies, poliovirus 1, adenovirus 5, and vaccinia virus seeded into brackish waters from the Gulf of Gdansk survived for more than 60, 50 and 35 days, respectively, at temperatures that fluctuated between 1.5 and 23.5 C. From about 3 to about 60 TCD_{50} of the viruses/ml were still viable after these periods.

The poliovirus, adenovirus, and vaccinia virus were seeded into the brackish waters at concentrations of $10^{5.33}$ TCD_{50}/ml, $10^{4.1}$ TCD_{50}/ml, and $10^{5.75}$ TCD_{50}/ml, respectively.

λ

Block, J.-C., Joret, J.-C, Hartemann, P., Schwartzbrod, L., Dixneuf, P. (1977). *Evaluation of the Alginate Membrane Filter Method for the Concentration of Enteroviruses in Water.* **ZBL BAKT HYG, 165**:471-7. **German.**

From 47 to 80% of poliovirus 1 seeded into synthetic waters were recovered on alginate membranes. The efficiency of recovery of the seeded virus from drinking water was about the same. Recoveries were higher in drinking waters to which $AlCl_3$ had been added in a final concentration of 0.0005 M. The virus was recovered by dissolution of the membranes in sodium citrate buffer. Statistical error in the tests was considerable.

More recoveries of viruses were made from wastewaters by the alginate membrane technic than by the direct inoculation technic.

Alginate membranes were brittle and filtration through them was slow limiting the usefulness of the technic to small volumes of waters.

γ τ

Boardman, G. D., Sproul, O. J. (1977). *Protection of Viruses During Disinfection by Adsorption to Particulate Matter.* **J WATER POLLUT CONTRL FED, 49(8)**:1857-61.

Coliphage T7 adsorbed or attached to kaolinite clay, hydrated aluminum oxide, and calcium carbonate. Phages adsorbed to these particulate systems were not protected from inactivation in chlorinated waters. Thus, adsorption of phages to exposed surfaces provided negligible protection from disinfection.

ε μ γ

Brown, E. R., Sinclair, T., Keith, L., Beamer, P., Hazdra, J. J., Nair, V., Callaghan, O. (1977). *Chemical Pollutants in Relation to Diseases in Fish.* **ANN NY ACAD SCI, 298**:535-46.

Within a review of fish diseases in a clean and in a polluted water system, a study is described in which fathead minnows were reared for 11 months in well water, disinfected sewage effluent, and non-disinfected sewage effluent in a treatment plant in Wyoming, Michigan. Six to seven times as many lesions were found in the minnows reared in nondisinfected sewage effluent and in chlorinated effluent than in minnows reared in well water. Fish reared in dechlorinated chlorinated effluent, in ozonated effluent, and in effluents disinfected with BrCl suffered two to four times as many lesions as the minnows reared in well water did.

Polioviruses were recovered from the lower intestinal tracts of fish reared in non-disinfected sewage effluents and in effluents disinfected with ozone and BrCl.

ξ ζ χ θ μ σ

Bryan, F. L. (1977). *Diseases Transmitted by Foods Contaminated by Wastewater.* **J FOOD PROTECT, 40(1)**:45-56.

In a review of diseases transmitted by foods contaminated by wastewater, the recovery and survival of pathogens in sewage and in soils and foods contaminated by wastewater are extensively documented. Among the pathogens included were hepatitis A virus and other viruses.

π

Chassard-Bouchaud, C., Hubert, M., Bonami, J.-R. (1976). *Virology of Invertebrates—Particles of Viral Nature Associated with the Y Organ of the Crab* Carcinus maenas. **CR ACAD SCI, 282(16)**:1565-6. **French.**

Enveloped, ovoid, virus-like particles 150 to 170 nm long and 70 to 90 nm wide were detected in the Y organ of the crab *Carcinus maenas*. Spikes on the envelope measured 7 to 10 nm in length. The virus-like particles appeared to form by budding through plasma membranes.

π

Comps, M. M., Bonami, J.-R., Vago, C., Campillo, A. (1976). *Pathology of Invertebrates. A Virus of Portuguese Oysters* (Crassostrea angulata LMK). **CR ACAD SCI, 282(22)**:1991-3. **French.**

Virions larger than poxviruses and iridoviruses were detected in Portuguese oysters (*Crassostrea angulata*) that succumbed during an epizootic

from 1970 to 1973. The capsids of the virions possessed cubic symmetry and were enclosed in double membranes. The diameters of the viruses were about 350 nm.

π

Comps, M. M., Duthoit, J.-L. (1976). *Virus Infection with Gill Disease of the Portuguese Oyster* Crassostrea angulata. **CR ACAD SCI, 283(14)**:1595-6. **French.**

Virus-like particles and lesions characterized by hypertrophy were observed in Portuguese oysters with gill disease.

η σ

Cooper, R. C., Golueke, C. G. (1977). *Public Health Aspects of On-Site Waste Treatment.* **COMPOST SCI, 18(3)**:8-11.

The hazard of viruses and other pathogens in human wastes is alluded to within an extensive discussion of the risks and problems in disposing of such wastes to the land.

γ

Cottet, J. (1976). *The Disinfection of Drinking Waters and Sewage by UV-Rays.* **L'EAU, 39(3-4)**:20. **Translation presently not available. French**

ρ χ σ τ

Damgaard-Larsen, S., Jensen, K. O., Lund, E., Nissen, B. (1977). *Survival and Movement of Enterovirus in Connection with Land Disposal of Sludges.* **WATER RES, 11(6)**:503-8.

Coxsackievirus B3 and tritium were seeded into anaerobically digested municipal sludges that were placed over sandy soil or clay in lysimeters in Denmark. During a normal Danish winter, 23 weeks were required to inactivate the 10^5 $TCID_{50}$ of viruses that had been seeded into each gram of sludge. The virus did not penetrate either the soil or clay.

Three hundred mm of rain fell during the December to May period of the study.

χ

Denis, F. A., Dupuis, T., Denis, N. A., Brisou, J. F. (1977). *Survival in Seawater of 20 Strains of DNA and RNA Viruses.* **J FRAN HYDROL, 8(22)**: 25-36. **French.**

In laboratory studies, 99% of seeded poliovirus 2 was destroyed in natural seawater in 24 days at 4 C and in six hours at 22 C. For 99% destruction of the poliovirus in synthetic, filtered, and autoclaved sea water at 4 C, 380 to 450 days were required.

With other strains of polioviruses, up to 72 days were required for 99% destruction in natural seawater at 4 C. In natural seawater at 4 C, echovirus 6 required 120 days for 99% destruction, echovirus 30 required 96 days, herpesviruses and poxviruses only 1 to 12 days. Survivals were usually much longer in autoclaved seawater.

Biological factors probably play an important role in the destruction of viruses in seawater.

π

Di Girolamo, R., Liston, J., Matches, J. (1977). *Ionic Bonding, the Mechanism of Viral Uptake by Shellfish Mucus.* **APPL ENVIRON MICROBIOL, 33(1)**:19-25.

Studies in which secreted shellfish mucus was selectively degraded, and carboxyl and sulfate groups on the mucus were chemically blocked indicated that virions attached to mucus pri narily by ionic bonding to sulfate radicals on the mucopolysaccharide moieties of the mucus.

ξ λ

Drapeau, A. J., Hoang Van, H., Dumoulin, P. P. (1976). *Techniques for Concentrating Viruses from Water Treated for Public Distribution.* **ANNEE BIOL, 15(11-12)**:486-518. **French**

The methods available for detecting viruses in water are extensively reviewed and discussed.

δ μ

Drozdov, S. G., Kazantseva, V. A. (1977). *Significance of Virological Examinations of Sewage: Comparison of Isolations of Enteroviruses from Sewage and from Feces of Virus Carriers.* **VOPR VIRUSOL, 5(9-10)**: 597-602. **Russian.**

When an enterovirus was excreted by 10% of the children in a community, that virus was usually recovered from the sewage of the community.

Enteroviruses recovered from only occasional excretors were not detected in sewage.

ρ ν

Eisenhardt, A., Lund, E., Nissen, B. (1977). *The Effect of Sludge Digestion on Virus Infectivity.* **WATER RES, 11(7)**:579-81.

Coxsackievirus B3 seeded into raw sewage sludge was destroyed at a rate of 99%/24 hours in an anaerobic sludge digester with a 35-day detention time maintained at 35 C. The pH of the sludge was about 7. The digester was fed daily.

ξ

Elliott, L. F., Ellis, J. R., (1977). *Bacterial and Viral Pathogens Associated with Land Application of Organic Wastes.* **J ENVIRON QUAL, 6(3)**:245-51.

The hazards of discharging to the land raw and treated sewages that contain viruses and pathogenic bacteria are reviewed and discussed.

α ι μ

Fannin, K. F., Gannon, J. J., Cochran, K. W., Spendlove, J. C. (1977). *Field Studies on Coliphages and Coliforms as Indicators of Airborne Animal Viral Contamination from Wastewater Treatment Facilities.* **WATER RES, 11(2)**: 181-8.

Activated sludge and trickling filter effluents contained about 100 PFU of viruses/liter when assayed on Buffalo Green Monkey (BGM) cells, about 400,000 PFU of coliphages/liter and 2,000,000,000 CFU of total coliforms/liter. No airborne animal viruses were recovered with large-volume air samplers, but airborne coliphages collected with such samplers ranged in numbers from 23 to 30 MPN/m^3 of air. Anderson samplers recovered 210 CFU of total coliforms/m^3 of aerosol.

Ratios of coliphages to animal viruses in effluents indicated that wastewater treatment plants were continuous sources of small numbers of animal viruses in aerosols.

Coliphages are more stable than coliforms in the airborne state and may be better indicators of airborne viruses than coliforms.

λ

Farrah, S. R., Gerba, C. P., Goyal, S. M., Wallis, C., Melnick, J. L. (1977). *Regeneration of Pleated Filters Used to Concentrate Enteroviruses from Large Volumes of Tap Water.* **APPL ENVIRON MICROBIOL, 33(2)**:308-11.

Pleated epoxy-fiberglass cartridge filters that concentrate enteroviruses from volumes of more than 2,000 liters of tap water were regenerated by treatment with 0.1 N NaOH or by autoclaving. The regenerated filters regained their ability to concentrate viruses from water at high flow rates.

λ

Farrah, S. R., Goyal, S. M., Gerba, C. P., Wallis, C., Melnick, J. L. (1977). *Concentration of Enteroviruses from Estuarine Water.* **APPL ENVIRON MICROBIOL, 33(5)**:1192-6.

Poliovirus 1 seeded into 400 liters of estuarine water was recovered on pleated, epoxy-fiberglass cartridge filters. Adsorption was accomplished at pH 3.5 in the presence of 0.0015 M $AlCl_3$. The cartridge filters had a porosity of 0.45 μm. Adsorbed viruses were eluted from the filters with three liters of glycine buffer, pH 11.5. Seventy percent of the seeded viruses were recovered.

Eluates from estuarine waters that contained large amounts of organic compounds could not be reconcentrated by filter adsorption-elution technics. Thus, viruses in three liters of filter eluate were adsorbed to aluminum hydroxide flocs and then eluted in 150 ml of buffered fetal calf serum. Further reductions in volume were achieved by ultrafiltration or by hydroextraction. With these procedures, 60 to 80% of the viruses in three liters of filter eluate were recovered in a final volume of 10 to 40 ml.

λ

Fattal, B., Katzenelson, E., Hostovsky, T., Shuval, H. I. (1977). *Comparison of Adsorption-Elution Methods for Concentration and Detection of Viruses in Water.* **WATER RES, 11(11)**:955-8.

Seventy-seven percent of an attenuated strain of poliovirus 1 seeded into a 20-liter quantity of Jerusalem tap water was recovered by the membrane-adsorption technic when the adsorbed virions were eluted with 3% beef extract. Sixty-five percent of the virus was recovered by the same technic with high pH elution, 70% with the PE60 method, and 50% with the $Al(OH)_3$ method.

When domestic raw sewage that contained enteroviruses was seeded into 20-liter quantities of tap water, all of the viruses were quantitatively recovered by the membrane adsorption technic when the adsorbed virions were eluted with 3% beef extract. Eighty percent of the virions were recovered by the PE60 technic, 67% by the membrane adsorption technic with high pH elution, and 40% by the $Al(OH)_3$ technic.

Seeding concentrations ranged from 160 to 3,300 PFU with the poliovirus and 12 to 472 PFU with the enteroviruses in sewage.

μ
Fattal, B., Nishmi, M. (1977). *Enterovirus Types in Israel Sewage.* **WATER RES, 11(4)**:393-6.

Enteroviruses were recovered from sewage in communities in Israel by the grab sample and gauze pad technics. Of 489 viruses recovered from sewage by the picked plaque method during 1968 to 1970, 74% were polioviruses, 10% were coxsackievirus B, coxsackievirus A9, or echovirus 9, and 16% were other enteroviruses.

ξ δ
Feachem, R. G. (1977). *Infectious Disease Related to Water Supply and Excreta Disposal Facilities.* **AMBIO, 6(1)**:55-8.

Some viruses transmitted by water or transmitted under conditions of poor hygiene are discussed within a broad review and discussion of diseases associated with water sources and feces disposal.

ξ λ
Fenters, J. D., Reed, J. M. (1977). *Viruses in Water Supply.* **J AMER WATER WORKS ASSN, 69(6)**:328-31.

The methods used for recovering viruses from water are reviewed and discussed.

η
Floyd, R., Sharp, D. G., (1977). *Aggregation of Poliovirus and Reovirus by Dilution in Water.* **APPL ENVIRON MICROBIOL, 33(1)**:159-67.

When diluted 10-fold into distilled water from a little-aggregated stock (in 0.05 M phosphate buffer, pH 7.2, and 22% to 30% sucrose), poliovirus 1 and reovirus 3 aggregated into clumps of up to several hundred particles. The reovirus also aggregated when diluted into phosphate-buffered saline. The aggregations were concentration-dependent and did not occur when either viruses was diluted 100-fold or greator into water.

The aggregation of the poliovirus was reversed by sufficient dilution in saline. The aggregation of the reoviruses was not. Both viruses aggregated when diluted into buffers at pH 5 and 3, and the poliovirus aggregated at pH 6. Aggregation of both viruses reversed at pH 7.

Aggregation did not occur at alkaline pH levels, and aggregation at low pH could be prevented by sodium or magnesium ions. Neither ion caused aggregation of either virus at pH 7. Calcium ions, however, at a concentration of 0.01 M, aggregated both viruses.

The initial concentrations of viruses in the preparations used in this study ranged from about 10^{10} to 10^{12} virions/ml.

ν
Foster, D. H., Engelbrecht, R. S., Snoeyink, V. L. (1977). *Application of Weak Base Ion-Exchange Resins for Removal of Proteins.* **ENVIRON SCI & TECHN, 11(1)**:55-61.

A phenol-formaldehyde synthetic resin (Diamond Shamrock Duolite A-7) adsorbed coliphage MS2 from wastewater, but the effectiveness of the sorbent resin was significantly reduced by organics in the wastewater that competed with the viruses for adsorption sites on the resin.

λ τ

Gerba, C. P., Smith, E. M., Melnick, J. L. (1977). *Development of a Quantitative Method for Detecting Enteroviruses in Estuarine Sediments,* **APPL ENVIRON MICROBIOL, 34(2)**:158-63.

Seeded poliovirus 1 adsorbed readily to natural marine sediments collected along the Texas Gulf coast and was eluted from sediments with 10% fetal calf serum and 0.01 M ethylenediaminetetraacetate (EDTA) in 0.25 M glycine buffer, pH 10.5. Sixty percent of the seeded viruses were recovered.

Because the calf serum eluate could not be reconcentrated, large volumes of sediment were eluated with 0.05 M EDTA in 0.25 M glycine buffer, pH 11.5, and the eluate was reconcentrated by membrane filtration at pH 3.5 in the presence of 0.06 M $AlCl_3$. The final volume of eluate was 30 to 50 ml. Fifty percent of the seeded polioviruses were recovered from the sediment with this technic.

γ

Gerba, C. P., Wallis, C., Melnick, J. L. (1977). *Application of Photodynamic Oxidation to the Disinfection of Tapwater, Seawater, and Sewage Contaminated with Poliovirus.* **PHOTOCHEM PHOTOBIOL, 26(5)**:499-504.

Poliovirus1 (LSc), seeded into tapwater, sewage, or seawater, was inactivated by visible light after sensitization by methylene blue. At pH 10, almost 2.5 logs of the virus were inactivated in 5 minutes by 670 nm light (20 W/m^2) in waters that contained 13 μM of methylene blue. The virus had been sensitized in the dark to the dye for 24 hours before it was exposed to the light.

The inactivation curves for the virus were of the multi-hit type regardless of dye concentration, pH, temperature, sensitization time, nature of suspending solution, or sequence of exposure to light.

Preincubation of the dye-virus mixture in the dark at 24 C increased the rate of subsequent photoinactivation of the virus. Dye concentrations above 26 μM did not substantially increase the rate of photoinactivation.

Significant inactivation of the virus in the dark occured at high dye concentrations.

γ

Gerba, C. P., Wallis, C., Melnick, J. L. (1977). *Disinfection of Wastewater by Photodynamic Oxidation.* **J WATER POLLUT CONTRL FED, 49(4)**: 575-83.

After sensitization in the dark for four hours by 1 mg/liter of methylene blue at pH 10, more than eight log units of a coliform bacterium seeded into wastewater were destroyed by exposure for 1 minute to 2,000 μW of light/cm^2 at a wavelength of 670 nm. In similar circumstances, seeded poliovirus 1 (LSc) was destroyed more slowly. Sensitized in the dark by 5 mg/liter of methylene blue at pH 10 for 24 hours, two log units of the poliovirus were destroyed in about 5 minutes by exposure to the same quantity of 670 nm light.

The effectiveness of methylene blue as a light-sensitizing agent increased with increasing pH, apparently because methylene blue ionizes as pH declines. The inactivating effect of the light increased with longer periods of sensitization, with higher concentrations of methylene blue, and with higher temperatures.

At the dye concentrations studied, methylene blue alone destroyed the coliforms during the sensitization period but not the poliovirus.

Methylene blue combines with DNA in the dark and oxidizes and disrupts it upon exposure to 670 nm light. In procaryotes, metabolic enzymes may be destroyed also.

ν γ

Goncharuk, E. I., Koganovsky, A. M., Girin, V. N., Salata, O. V. (1976). *Hygienic Assessment of Tertiary Adsorption Treatment of Domestic Sewage and Industrial Effluent.* **GIG SANIT, 0(11)**:36-9. **Russian.**

In laboratory studies with virus- and pathogenic bacteria-seeded biologically-treated sewage effluents, activated carbon removed 98.8% of attenuated poliovirus 2, 97% of coxsackievirus B6, 96% of coliphage T2, and about 99% of *Salmonella typhimurium, Shigella sonnei,* and *Escherichia coli* O-111.

All of the seeded bacteria in the carbon-treated tertiary effluents were destroyed within 30 minutes by 1.5 to 2 mg of chlorine/liter. Destruction of all of the viruses in the effluents required chlorine dose-time couplings of 5 mg/liter and two hours or 10 mg/liter and 30 minutes.

λ μ

Grigoreva, L. V., Korchak, G. I. (1977). *Methods for the Concentration of Viruses in Water.* **GIG SANIT, 0(6)**:62-4. **Russian.**

Poliovirus 1 seeded into tap water was recovered on gauze pads and then concentrated by adsorption onto and elution from polyacrylamide. In this two-step method, elution was accomplished with 0.5 M phosphate buffer.

In wastewaters, twice as many viruses were recovered with this two-step procedure as with a one-step procedure in which the virus was concentrated by adsorption to and elution from anionite AV-17.

Bacteriophage M1S2 was concentrated from seeded tap waters by these methods also.

ν

Guy, M. D., McIver, J. D., Lewis, M. J. (1977). *The Removal of Virus by a Pilot Treatment Plant.* **WATER RES, 11(5)**:421-8.

In a pilot water treatment plant, flocculation with 40 mg of $Fe_2(SO_4)_3$/liter and sedimentation removed from 93% to >99.7% of indigenous phages, seeded vaccine strains of polioviruses 1, 2, and 3, and seeded coliphage T4.

The rapid sand filter and the activated carbon column each removed about 78% of seeded viruses, but were about half as efficient after they were backwashed. Viruses were not recovered from final effluents that contained a free chlorine residual of 0.4 mg/liter.

The total plant was capable of removing >99.9995% of influent viruses.

π μ

Harshbarger, J. C., Chang, S. C., Otto, S. V. (1977). *Chlamydiae (with Phages), Mycoplasmas, and Rickettsiae in Chesapeake Bay Bivalves.* **SCIENCE, 196(4290)**:666-8.

Intracytoplasmic *Chlamydia*-like organisms, some with phages, *Rickettsia*-like organisms, and *Mycoplasma*-like organisms have been detected by electron microscopy in clams and oysters harvested from Chesapeake Bay waters.

None of these organisms have been detected before in mollusks, nor have phages been detected before in chlamydiae.

$\beta\ \delta$

Heinz, F., Bindas, B., Červenka, P., Zdébská, E. (1976). *Epidemics of Swimming Pool Conjunctivitis Caused by Adenovirus Type 3.* **CS EPIDEMIOL, 25(6)**:321-5. **Czechoslovakian.**

An epidemic of adenovirus 3 conjunctivitis occured in swimmers during a swimmer training course in a school at Vsetin. More than 48% of the children in the training course fell ill with conjunctivitis and acute respiratory disease.

$\mu\ \iota\ \nu$

Hoehn, R. C., Randall, C. W., Bell, F. A., Jr., Shaffer, P. T. B. (1977). *Trihalomethanes and Viruses in a Water Supply.* **J ENVIRON ENGIN DIV, ASCE, 103**:EE5:803-14.

Poliovirus 1 was recovered from finished waters of the Occoquan system. Two recoveries of viruses were made at the water treatment plant, and two recoveries were made at sampling locations in the distribution system. Each recovery was made on a different day during the summer of 1975.

Poliovirus 1 was also recovered from the raw waters at the water intakes of the treatment plant and from the stream above and below the intakes. Total coliform counts at these sampling locations ranged from 130 to 7,900/100 ml. All of the polioviruses were virulent by marker tests.

The viruses were recovered from waters concentrated on filters by the Baylor concentrator technic and detected in BGM and in primary monkey kidney cells.

The finished waters from which viruses were recovered had undergone coagulation, sedimentation, filtration, and chlorination to a total chlorine residual (mostly free) of 1.3 to 1.7 mg/liter.

Trihalomethanes, mostly chloroform, were formed during chlorination of finished waters. Discharge of chlorinated sewage did not alter appreciably the trichloromethane concentration of the receiving tributary.

$\xi\ \pi\ \theta$

Hughes, J. M., Merson, M. H., Gangarosa, E. J. (1977). *The Safety of Eating Shellfish.* **J AMER MED ASSN, 237(18)**:1980-1.

The transmission of hepatitis A by the consumption of uncooked and partially cooked bivalve shellfish is discussed within a broad review of shellfish-transmitted disease.

$\mu\ \nu$

Iostovetskii, Y. K., Tolstopyatova, G. V., Chudova, I. G., Yerusalimskaya, L. F., Didenko, O. V., Radzanovskii, A. A. (1977). *Sanitary Evaluation of Effectiveness of Urban Sewage Purification in Oxidation Ponds.* **GIG SANIT, 0(1)**:81-5. **Russian.**

In the winter, the number of total coliforms, all bacteria (total counts), and bacteriophage were almost as high in the effluents of oxidation ponds as in the influents. However, the numbers of enterococci were about 90% lower in the effluents than in the influents.

In the summer, total coliform numbers and total counts were about ten times higher in the effluents than in the influents, but the numbers of bacteriophages were three times higher in the influents than in the effluents.

Enteric viruses were also present in the effluents.

λ

Katzenelson, E. (1976). *A Rapid Method for Quantitative Assay of Poliovirus from Water with the Aid of the Fluorescent Antibody Technique.* **ARCH VIROL, 50**:197-206.

Fluoresceinisothiocyanate-labeled gamma globulin preparations (adsorbed with Vero cell powder) mixed with rhodamine-labeled bovine albumin stained poliovirus 1-infected BGM cells that had been washed with acetone.

Stained single infected cells fluorescing green against a background of reddish brown-rhodamine-stained normal cells were distinguishable nine hours after infection indicating that bursts had occured ending the first cycle of infection. Counts of fluorescent centers 18 to 20 hours after infection were similar in numbers to plaque counts, but counts of centers nine hours after infection were somewhat lower. Moreover, distinguishing non-specific fluorescence was difficult with nine-hour stainings.

Plaque counts of poliovirus 1 recovered from seeded tap water gave a fair correlation with fluorescent center counts, with the plaque counts tending to be higher.

Contamination of the cultures was a lesser problem with the shorter-incubation fluorescence technic than with the plaque technic.

With improvement in the quality of the labeled gamma globulin preparations, the 18 to 20 hour incubation period needed for the fluorescence technic, already several days shorter than that needed for plaque assay, may be reducible to nine hours.

ξ λ

Katzenelson, E. (1977). *Concentration and Identification of Viruses from Sea Water.* **REV INT OCEANOGR MED, 48**:9-16.

Methods for recovering viruses from saline waters are reviewed within a discussion of the problem of viruses in seawater.

χ

Kokina, A. G., Lukashevich, N. A., Novitskaya, N. V., (1977). *Effect of Chemical and Microbiological Quality of Groundwater on the Survival of Enteroviruses and Enterobacteria.* **GIG SANIT. 0(5)**:111-3. **Russian.**

In waters from clean and contaminated wells, echovirus 7 survived for up to 66 days at 20 C and for up to 113 days at 10 C. Coxsackievirus B3 survived almost as long, but poliovirus 1 (LSc) survived only about half as long as the echovirus survived.

Escherichia coli survived for up to 76 days at 10 C in these well waters and for up to 57 days at 20 C. Under similar conditions, *Salmonella typhi* survived for at least half as long, but *Shigella sonne* and *Shigella flexneri* usually survived for only six or seven days at both temperatures.

The viruses had been seeded into the well waters at concentrations of 2×10^4 TCD_{50}/liter. The bacteria had been seeded at concentrations of 10^5 CFU/liter.

λ ζ

Konowalchuk, J., Speirs, J. I. (1977). *Virus Detection on Grapes.* **CAN J MICROBIOL, 23(9)**:1301-3.

Poliovirus 1 and coxsackievirus B5 inoculated into grapes were recovered equally well by washes in water, 0.5% polyethylene glycol, and phosphate-

buffered saline that contained 1% serum.

Many of the viruses in the water wash were noninfective until treated with 0.5% polyethylene glycol.

ι ν χ

Kott, Y. (1977). *Some Thoughts Concerning Water Pollution Indicators.* **ISREAL J MED SCI, 13(6)**:646.

Coliphages may serve as indicators of enteric viruses in waste and other waters. Coliphages are present in waste and other waters in which human enteric viruses are present and in numbers at least equal to the numbers of enteric viruses present. Coliphages are more resistant to chlorine than enteroviruses. Coliphages persist in sand columns for months longer than poliovirus 1 does. During several breakdowns in water supply treatment systems, 10 to 1,000 times more coliphages than enteroviruses were recovered from these systems.

ν

Lance, J. C., Gerba, C. P. (1977). *Nitrogen, Phosphate and Virus Removal from Sewage Water During Land Filtration.* **PROG IN WATER TECHNOL, 9(1)**:157-66.

Most of the poliovirus 1 (LSc) seeded into secondary sewage effluents was removed in the top few centimeters of a column of loamy sand from the dry Salt River bed near Phoenix. Few of the viruses were detected in the column below the 160 cm depth.

Most of the nitrogen and phosphorus in the sewage was also removed by the column.

See in 1976 Literature Abstracts: **Lance, J. C., Gerba, C. P. Melnick, J. L.** (1976). *Virus Movement in Soil Columns Flooded with Secondary Sewage Effluent.* **APPL MICROBIOL, 32(4)**:520-6.

λ

Lepakhina, N. K. (1977). *Concentration of Poliovirus and Coliphages on Ion-Exchange Resins.* **GIG SANIT, 0(2)**:56-9. **Russian.**

Polioviruses and coliphages were concentrated from waters by anionic-exchange resins designated AV-17-IK, AV-17-8, AN-22D, and AN-31G. The effective resins for this purpose were AV-17-IK and AN-31G. The optimal pH range for concentrating the viruses on the resins was 5.5 to 6.5. The addition of 10 gm of $CaCl_2$ to each liter of test water increased the numbers of viruses adsorbed to the resins.

Concentration of viruses was most effectively achieved from volumes of at least three liters of water and from waters that did not contain heavy organic loadings.

The viruses were eluted from the resins with an elutant that contained beef extract and 10% bovine serum in Earles' balanced solution, pH 8.2.

Bacteriophages were concentrated somewhat less effectively than polioviruses were.

ν

Lo, S. H., Sproul, O. J. (1977). *Polio-Virus Adsorption from Water Onto Silicate Minerals.* **WATER RES, 11(8)**:653-8.

In batch studies, from 64 x 10^4 to 89 x 10^4 PFU of poliovirus 1 was adsorbed/mg of the silicate minerals actinolite, enstatite, kyanite, microcline, olivine and sillimonite. In a continuous flow column, microcline was equally

effective. Extraneous organic matter competed for adsorption sites and also desorbed the virus. Under groundwater flow conditions, the virus broke through the column more rapidly when the virus was adsorbed from a secondary effluent than when it was adsorbed from a clean water.

χ

Mahnel, H., Ottis, K., Herlyn, M. (1977). *Stability in Drinking and Surface Water of Nine Virus Species from Different Genera.* **ZBL BAKT HYG, 164(1-2)**:64-84. **German.**

At 9 C, with initial virus concentrations of about 10^6 infectious units/ml, Teschen, vaccina, reovirus, HCC, and Newcastle disease viruses survived in natural waters for more than 200 days. Under similar conditions, foot and mouth disease, Aujeszky, vesicular stomatitis, and Sindbis viruses survived for 20 to 50 days.

It is probable that in natural waters with small amounts of viruses present initially, even among the labile togaviruses, herpesviruses, rhabdoviruses, and the pH labile picornaviruses, some virions remain infective for some days. Paramyxoviruses may remain infective for weeks. None of these viruses, however, are important contaminants of water.

Very stable viruses such as enteroviruses, reoviruses, adenoviruses and poxviruses may remain viable for weeks to months. Of these only poxviruses are not important contaminants of water.

Water hardness, pH, and a number of other factors did not affect the survival of these viruses. However, viruses were more stable at lower temperatures than at higher temperatures.

λ μ

Maini, P., Piva, I. (1977). *Isolation of Viruses from Urban (Ferrara) Sewage: Comparison of Methods.* **BOLL IST SIEROTER MILAN, 56(3)**:201-5. **Italian.**

The aluminum hydroxide procedure was significantly better than the polymer two-phase separation, cellulose membrane filtration, and direct inoculation procedures for recovering viruses from raw sewage. Viruses were recovered on Vero and HEP2 cells. The two-phase separation procedure was about equal to the direct inoculation method. No recoveries of viruses were made on membrane filters (Sartorius SM113) at pH 3 in the presence of $MgCl_2$.

All viruses recovered were adenoviruses.

μ ν γ

Malakhova, T. S. (1977). *Presence of Enteroviruses in Sewage After Purification.* **MIKROBIOL ZH, 39(2)**:228-9. **Ukrainian.**

From 1972 to 1975 in the Ukraine, enteroviruses were recovered from 86 (17.6%) of 486 sewage samples studied. Enteroviruses were also recovered from sewage in a treatment plant at all stages of treatment and after chlorination.

Maximum numbers of virus recoveries were made between June and November.

μ

Malakhova, T. S., Leibenzon, A. S. (1977). *Sanitary Virological Study of Dnieper River Water in the Region of a Drinking Water Supply Intake.* **GIG SANIT, 0(6)**:62-4. **Translation presently not available. Russian.**

ξ ν

Melnick, J. L., Gerba, C., Wallis, C. (1977). *Viruses in Water: Growing Urgency of the Problem and Approaches to its Resolution.* **VESTN AKAD MED NAUK SSR, 0(6)**:70-5. **Russian.**

The problems of viruses in water and wastewater and the removal of viruses from the environment by treatment processes are extensively reviewed.

ρ χ σ

Moore, B. E., Sagik, B. P., Sorber, C. A. *An Assessment of Potential Health Risks Associated with Land Disposal of Residual Sludges.* **In "Sludge Management Disposal and Utilization," Proceedings of the Third National Conference on Sludge Management Disposal and Utilization. Information Transfer Inc., Rockville, Maryland** (1977), 108-12.

More than 90% of the enteroviruses in activated sludge mixed liquors are solids-associated. Enteroviruses seeded into raw or digested sludges are inactivated at a rate of approximately 90%/24 hours when the temperature is in the range of 25 to 35 C.

There seems to be an optimal moisture content in soil that favors virus survival. Viruses do not survive as long in dry soils as in soils with moisture contents of 15 to 25%.

Viruses adsorbed to soils are released during distilled water washes as cation concentrations are reduced.

γ

Muzychuk, N. I., Vorobeva, A. M., Kulskij, L. A., Matskevich, E. S. (1977). *On the Problem of Intensifying Action of the Electric Field in the Processes of Water Disinfection.* **DOPOV AKAD NAUK UKR, 0(8)**:750-3. **Ukrainian.**

Viruses and bacteria in autoclaved tap water were destroyed by cations in an electric field generated between two graphite electrodes 40 mm apart.

In an electrical field of thirty V/cm, at a current of 280 mA, 0.5 mg of Ag^{+}/liter or 9.8 mg La^{+3}/liter destroyed 54% of coxsackievirus A21, 56% of coxsackievirus B6, 78% of poliovirus 2, and 99% of coliphage T2 in three minutes. *Escherichia coli, Shigella sonnei,* and *Salmonella typhimurium* were destroyed more rapidly. Resistance of the viruses and bacteria to the cations in the electric field decreased in the following order: coxsackievirus A21> coxsackievirus B6> coliphage T2>*E. coli*>*S. sonnei*>*S. typhimurium.*

Cd^{+2}, Co^{+2}, Mn^{+2}, Na^{+2}, Zn^{+2} were also microbicidal in the electric field.

Direct current was more effective than alternating current.

χ ν

Nagel, R., Straub, O. C., Strauch, D. (1976). *The Rotating Aeration (System FUCHS) for Treatment of Liquid Animal and Municipal Wastes. 6. Preliminary Investigations on the Effect of Aerobic Treatment of Pig Slurry Containing a Bovine Enterovirus.* **BERL MUNCH TIERAERZTL WOCHENSCHR, 89(22)**: 443-5. **German.**

A bovine enterovirus (CBV-D) seeded into a pig slurry in a concentration of $10^{2.5}$ TCD_{50}/ml survived in a rotating aeration system for 30 hours at pH 6.6 and temperatures up to 48 C and for 22 hours at pH 9.2 and temperatures up to 30 C.

Within a glass ampule, the virus survived even longer under otherwise similar conditions.

μ
Nestor, I., Costin, L., Sovrea, D., Ionescu, N. (1977). *Enteroviruses in Romanian Zones of the Danube and Black Sea.* **VIROLOGIE, 28(3)**:207-12.

Polioviruses 1 and 2 and a coxsackievirus A were recovered from five of 33 water and sand samples collected along the coast of the Black Sea during the summer of 1975. All of the polioviruses were vaccine-like. Water samples were collected by the high-volume gauze pad technic.

Because there were no sewage discharges in the area and because the number of viruses recovered from the Danube, which empties into the Black Sea in this area, was small, the source of the viruses was believed to be bathers in the area.

χ
O'Brien, R. T., Newman, J. S. (1977). Inactivation of Polioviruses and *Coxsackieviruses in Surface Water.* **APPL ENVIRON MICROBIOL, 33(2)**: 334-40.

In studies with membrane dialysis chambers immersed in the Rio Grande (23 to 27 C), 90% inactivation of poliovirus 1, poliovirus 3, and coxsackievirus A13 occurred in 25, 19, and 7 hours, respectively. At 4 to 8 C, 90% inactivation of poliovirus 1 and coxsackievirus B1 occurred in 46 and 58 hours, respectively.

Studies with labeled poliovirus 1 and labeled coxsackievirus B1 and with infectious viral RNA indicated that inactivation of these viruses was brought about by damage to the viral RNA.

Throughout the year, inactivation of viruses occurred more rapidly in natural Rio Grande water than in heat-sterilized Rio Grande water.

ν
Oza, P. P., Chaudhuri, M. (1976). *Virus-Coal Sorption Interaction.* **J ENVIRON ENGIN DIV, ASCE, 102:EE6**:1255-62.

Bituminous coal adsorbed seeded coliphage MS2 from water. Adsorption of viruses increased with increasing ionic strength and temperature, and decreased with increasing pH. The adsorption of viruses to the coal was consistant with the Langmuir equation and with irreversible second-order reaction kinetics. Adsorption of viruses to coal involved a specific interaction, presumedly hydrogen bonding, between the surface functional groups on the virus and the exterior surface of the coal.

ν
Oza, P. P., Chaudhuri, M. (1977). *Some Notes on Virus Sorption on Coal.* **J GEN APPL MICROBIOL, 23(1)**:1-6.

Coals with greater ratios of hydrogen to carbon (H/C) and hydrogen to oxygen (H/O) adsorbed greater numbers of the RNA-containing coliphage MS2 than coals with smaller H/C and H/O ratios. Bituminous Giridih coal, with relatively high H/C and H/O ratios, was more adsorptive than Churcha and Neyveli coals with relatively low H/C and H/O ratios.

In the presence of albumin, a competitor for adsorption sites, the numbers of coliphages adsorbed to Giridih coal were reduced. Wastewater components and the DNA-containing coliphage T4 similarly interfered with the adsorption of MS2 to the coal.

MS2 apparently adsorbed to bacteria, where these were present, and many of the bacteria adsorbed to the coal.

In column studies, Giridih coal removed more of the coliphages as column height increased and more efficiently as loadings of the phage decreased.

λμ

Primrose, S. B., Day, M. (1977). *Rapid Concentration of Bacteriophages from Aquatic Habitats.* **J APPL BACTERIOL, 42(3)**:417-21.

Five different coliphages seeded into water were adsorbed by filtration onto hydroxylapatite ($CaHPO_4$) and eluted with 0.8 M sodium phosphate buffer, pH 7.2. Recovery efficiencies ranged from 33% to 90%.

With this technic, 70 different phages were recovered from river waters.

ξ δ θ

Ramzin, S. K. (1975). *Protection of the Water from Virus Contamination.* **VODOPRIVREDA, 7(36-7)**:36-47. **Yugoslavian.**

The diseases associated with enteroviruses of man, the nature of those viruses, the epidemiology of hepatitis A and other infectious diseases (especially of viral etiology) in Yugoslavia and Serbia, and the need for good sewage treatment, especially disinfection, are reviewed.

ν λ

Rao, V. C., Lakhe, S. B., Waghmare, S. V., Dube, P. (1977). *Virus Removal in Activated-Sludge Sewage Treatment.* **PROG IN WATER TECHNOL, 9**:113-27.

From 1972 to 1974, in the tropical environment of Bombay, India, primary settling removed 29%, 65%, 52%, and 64% of the viruses in sewage during the monsoon, autumn, winter, and summer seasons, respectively. During these periods, the total removal of viruses by primary settling and the activated sludge process averaged 97%, 94%, 97%, and 97%, respectively.

Composites of hourly grab samples collected from 7 AM to 12 noon were processed on the same day or on two successive days (blending and centrifugation on the first day and pH adjustment, centrifugation, filtration, and elution on the second day), and, with no loss of viruses, the eluates were stored for up to seven days in the refrigerator before they were assayed for viruses.

γ

Rogers, M. R., Kaplan, A. M., Vitaliano, J. J., Pillion, E. (1977). *Military Individual and Small Group Water Disinfecting Systems: An Assessment.* **MILITARY MED, 141(4)**:268-77.

The usefulness of Globaline (buffered tetraglycine hydroperiodide) as a water disinfectant is reviewed.

When dissolved in water, Globaline releases I_2 slowly into solution. Elemental iodine, and its hydrolysis product HOI, are rapid bactericides and virucides.

Globaline, long used as a canteen disinfectant by the military, is also used today by campers and travelers.

μ

Ruschi, A., Matteucci, D. (1975). *Search for Cytopathic Viruses in Surface and Coastal Sea Water in the Province of Pisa, Italy.* **RIV ITAL IG, 35(4-6)**: 103-9. **Italian.**

Twenty-six percent of the samples from the Serchio River, 46% from the Morto River, 60% from the Arno River, and 65% from seawater collected near a sewage outfall yielded viruses in one or more different cell lines. Echoviruses, adenoviruses, polioviruses, and group A and B coxsackieviruses were recovered. The polioviruses recovered appeared to be of vaccine origin.

μ

Saleh, F. A. (1977). *Recovery and Susceptibility Patterns of Faecal* Streptococci *Bacteriophages.* **WATER RES, 11(4)**:403-9.

Nineteen of 20 sewage samples yielded at least one phage type on primary enrichment medium that contained $MgSO_4$ and L-tryptophan.

Host range studies for 16 phage types showed that phages that attacked *Streptococcus faecalis* and its two variants did not attack *S. fecium, S. bovis* or *S. equinus.*

λ

Sarrette, B. A., Danglot, C. D., Vilagines, R. (1977). *A New and Simple Method for Recuperation of Enteroviruses from Water.* **WATER RES, 11(4)**: 355-8.

The pH of ten liters of water seeded with 1 to 10^4 PFU of poliovirus 1 (LSc 2ab)/liter was adjusted with HCl to 3.5, and the water was injected under low pressure (0.15 bar) into the bottom of a column that contained 5 μm of powdered glass. The rate of flow of the water upward was adjusted to enable the powdered glass to remain in dynamic suspension. The polioviruses that adsorbed to the powdered glass were eluted with 50 ml of glycine buffer, pH 11.5 and thereby concentrated 200-fold. The recovery efficiency was 40% to 60% and did not depend upon the initial concentration of the virus in the water.

μ

Sattar, S. A., Westwood, J. C. N. (1977). *Isolation of Apparently Wild Strains of Poliovirus Type 1 from Sewage in the Ottawa Area.* **CAN MED ASSN J, 116(1)**:25-7.

In the first four months of 1974, viruses were recovered on BSC1 cells from 111 (79%) of 140 gauze pad samples collected in the Ottawa area. Of the 72 (65%) isolates identified by serology and electron microscopy, 56 (78%) were reoviruses and 16 (22%) enteroviruses. The enteroviruses recovered included one coxsackievirus B4, one vaccine strain of poliovirus 3, nine vaccine strains of poliovirus 1, and five strains of poliovirus 1 that were different from vaccine strains serologically and by temperature marker tests. That these strains were present in sewage when the immunity in the community against polioviruses was declining was a cause for concern.

μ σ

Schaub, S. A., Sorber, C. A. (1977). *Virus and Bacteria Removal from Wastewater by Rapid Infiltration Through Soil.* **APPL ENVIRON MICROBIOL, 33(3)**: 609-19.

Together with a front of percolating primary effluent, tracer coliphage f2 penetrated the unconsolidated silty sand and gravel of a rapid infiltration land wastewater application site and into groundwater. The site had been in continuous operation for more than 30 years. The phage did not concentrate on the upper soil layers.

The concentration of tracer phage in a 60-foot-(about 18.3-m-) deep observation well directly beneath the wastewater application area began to increase within 48 hours after the tracer was applied to the soil. The concentration of tracer phage in this well stabilized after 72 hours at a level of approximately 47% of the average applied concentration. Enteroviruses indigenous to the effluent and tracer coliphage f2 were detected in the groundwater sporadically at a horizontal distance of 600 feet (about 183 m) from the application zone.

Soil adsorption studies in the laboratory confirmed the poor adsorption of viruses noted at the site. This was especially true of surface soils seeded with wastewater.

Enteric indicator bacteria concentrated on the surface of the soil mat. However, some fecal streptococci that penetrated through the surface mat migrated into the groundwater and were detected at the same locations as the tracer phage and enteric viruses.

λ

Schwartzbrod, L., Block, J.-C., Dixneuf, P., Schwartzbrod, J., Brochet, J. C. (1975). *Concentration of Viruses in Water by the Polyme- Two Phase System: Quantitative Study.* **CR SEANCES SOC BIOL FIL, 169(3)**:641-4. **French.**

More than 75% of a poliovirus seeded into water was recovered with the polymer two-phase system. Usually, all of the viruses were recovered when about 100 infective doses of the virus were seeded into one liter of water. When greater numbers of infective doses were seeded into water, the efficiency of recovery with the polymer two-phase system diminished.

ρ ζ σ ι

Sedita, S. J., O'Brien, P., Bertucci, J. J., Lue-Hing, C., Zenz, D. R. *Public Health Aspects of Digested Sludge Utilization.* **In "Land as a Waste Management Alternative," edited by R. C. Loehr. Ann Arbor Science Publishers, Ann Arbor, Michigan** (1977), 391-410.

Anaerobically digested sludge (4% solids) from the Greater Chicago area is stored in holding basins and, primarily from April through October, applied to the land by spray or by incorporation into the soil. Corn is grown on most of the land.

Monthly tests for viruses showed annual averages that ranged from about 10 to several hundred infective doses of viruses/4 liters on a stream above the disposal site, 5 to 70 infective doses/4 liters on the same stream below the site, and 3 to 10 infective doses/4 liters at a reservoir that drained the application site. The numbers of infective doses of viruses recovered did not correlate well with the numbers of fecal coliforms, total coliforms, or fecal streptococci recovered.

Viruses were recovered on primary rhesus monkey kidney cells or on BGM cells from 4-liter samples of water by the aluminum hydroxide or PE60 technic.

The data were interpreted to mean that disposal of digested sludges to the land posed no health hazard from viruses.

ξ λ

Shaffer, P. T. B., Meierer, R. E., McGee, C. D. (1977). *Virus Recovery from Natural Water.* **J AMER WATER WORKS ASSN, 69(10)**:528-31.

The methods for recovering viruses from water are reviewed.

ν μ

Slade, J. S. (1977). *Enteroviruses in Partially Purified Water.* **J INST WATER ENGRS & SCIENTISTS, 31(3)**:219-24.

During the spring of 1975, reservoir storage, practiced by the Metropolitan Water Division of the Thames Water Authority brought about a marked reduction in the levels of viruses in the stored water, but significant numbers of viruses survived this treatment.

λ

Sobsey, M. D., Gerba, C. P. Wallis, C., Melnick, J. L. (1977). *Concentration of Enteroviruses from Large Volumes of Turbid Estuary Water.* **CAN J MICROBIOL, 23(6)**:770-8.

Seeded enteroviruses were recovered from 50-gallon (about 190-liter) quantities of turbid estuarine water by adsorption of the viruses onto 10-inch (about 25.4 cm) fiberglass depth cartridge and 2- and 0.65-μm epoxy-fiberglass filters arranged in series. The pH of the water was adjusted to 3.5, and $AlCl_3$ was added to a molarity of 0.0005 before the water was filtered.

Adsorbed viruses were eluted from the filters with basic glycine buffer (pH 11.5), and the eluate was reconcentrated in a precipitate formed by the addition of $FeCl_3$. The viruses were eluted from the precipitate with fetal calf serum.

The concentration factor was 9,000 to 12,000. The efficiency of concentration was 41%.

γ τ

Stagg, C. H., Wallis, C., Ward, C. H. (1977). *Inactivation of Clay-Associated Bacteriophage MS-2 by Chlorine.* **APPL ENVIRON MICROBIOL, 33(2)**: 385-91.

Freely suspended bacteriophage MS2 was inactivated by HOCl twice as quickly as MS2 adsorbed to bentonite.

The titer of unadsorbed viruses, clay concentration, cation concentration, temperature, stirring rate, and soluble organics affected the rate and extent of adsorption of the phage to the bentonite. The adsorption rate constant varied with stirring speed indicating that adsorption of the phage was a diffusion-limited process; the adsorption reaction had an apparent activation energy of 1 kcal/mol.

γ μ

Stanley, J. L., Cannon, R. E. (1977). *Serological Typing and Chlorination Resistance of Wastewater Cyanophages.* **J WATER POLLUT CONTRL FED, 49(9)**:1993-9.

A serological survey of *Lyngbya-Phormidium-Plectonema* (LPP)-attacking cyanophages at the North Buffalo Creek Sewage Treatment Plant in Greensboro, North Carolina showed that LPP-2 cyanophages predominated 9:1 over LPP-1 cyanophages.

In wastewater, combined chlorine residuals of 2.5 mg/liter inactivated 99% of stock strains of both LPP-1 and LPP-2 cyanophages in 17 minutes. Cyanophages recovered at the wastewater treatment plant were substantially more resistant to combined chlorine than laboratory strains of LPP-1 and LPP-2.

μ

Steinmann, J. (1977). *Detection of Viruses in Water of the Baltic Sea.* **ZBL BAKT HYG, 164(5-6)**:492-7. **Translation presently not available. German.**

ρ χ λ

Subrahmanyan, T. P. (1977). *Persistence of Enteroviruses in Sewage Sludge.* **BULL WLD HLTH ORG, 55(4)**:431-4.

Thirty-two percent of the poliovirus 1 homogenized into digested sludge was eluted with Earles' balanced salt solution (EBSS), pH 9.5. Recoveries in EBSS were lower at lower pH levels.

Enteroviruses seeded into sewage sludges at concentrations of several hundred to several thousand/ml (polioviruses 1 and 3, coxsackieviruses A9 and B2, B4, and B5, and echoviruses 6 and 9) survived for many weeks at room temperature.

The viruses in sewage sludges destined for land application should be inactivated before the sludges are discharged to the land.

ξ γ λ ν

Symons, G. E., Henderson, K. W. (1977). *Disinfection—Where are We?* **J AMER WATER WORKS ASSN, 69(3)**:148-54.

Within a general review of the status of drinking water disinfection, the need for better methods for detecting viruses in waters is underscored, and the effectiveness of water treatment procedures and disinfection for removing and destroying viruses in water are discussed.

χ

Tamási, G. (1977). *Studies on Microbiological Control of Liquid Manure Handling.* **WATER AIR SOIL POLLUT, 8(2)**:165-70.

Seeded into a filtered, sterilized pig manure extract, an echovirus survived for one week at 20 C and for six weeks at 4 C.

At both temperatures, seeded *Escherichia coli* and staphylococci survived for one week and aerobic spore formers for more than 30 days. Seeded lactobacilli survived for 3 and 13 days, and salmonellae for 4 and 28 days at 4 and 20 C, respectively.

The numbers of viruses and bacteria seeded were not given.

μ

Thraenhart, O., Kuwert, E., Worringen, W. (1977). *Poliomyelitis Surveillance in an Urban Population of the Ruhr Valley (Essen) by Virological Studies of Sewage.* **ZBL BAKT HYG, 164(4)**:328-39. **German.**

Laboratory-adapted wild-type poliovirus strains were readily detected by the monkey stable (MS) cell market test in each of 30 mixtures of different virus types and strains. The wild-type polioviruses were detected in only 22 of the 30 mixtures by the rct marker.

Replication kinetics of wild-type and vaccine strains of polioviruses in secondary monkey kidney cells and in MS cells were strain specific. This allowed tentative strain differentiations after two days of incubation.

In a field study, sewage was collected weekly over a five-month period at nine different points from the sewers of a large urban community (290,000 people). During this time no wild-type polioviruses were recovered, and no cases of poliomyelitis occurred.

ζ ρ χ

Tierney, J. T., Sullivan, R., Larkin, E. P. (1977). *Persistence of Poliovirus 1 in Soil and on Vegetables Grown in Soil Previously Flooded with Inoculated Sewage Sludge or Effluent.* **APPL ENVIRON MICROBIOL, 33(1)**:109-13.

Lettuce and radishes were planted in soil flooded with poliovirus 1-seeded sludge or effluent either one day before the planting or three days afterward. The poliovirus was detected up to 96 days after flooding during the winter months and up to 11 days after flooding during the summer months.

Poliovirus 1 was recovered from mature vegetables 23 days after flooding of the plots had ceased. Lettuce and radishes are usually harvested three to four weeks after planting.

γ ι

Tifft, E. C., Moffa, P. E., Richardson, S. L., Field, R. I. (1977). *Enhancement of High-Rate Disinfection by Sequential Addition of Chlorine and Chlorine Dioxide.* **J WATER POLLUT CONTRL FED, 49(7)**:1652-8.

Application of 25 mg of sodium hypochlorite (NaOCl)/liter or 12 mg of chlorine dioxide (ClO_2)/liter to combined wastewater overflows reduced the numbers of indicator bacteria and viruses to levels acceptable for discharge to recreational waters.

Twelve mg of ClO_2/liter destroyed 99.99% of seeded poliovirus 1 in 2 minutes. Coliphage f2 and ϕx 174 were destroyed by ClO_2 even more rapidly. NaOCl, as applied, destroyed the phages a little more slowly than the ClO_2 did. A 12 mg/liter-2 minute ClO_2-time coupling destroyed 99.9996% of total coliforms. Fecal streptococci were destroyed less rapidly by the same concentration-time coupling. NaOCl, as applied, destroyed both indicator bacteria more slowly than the ClO_2 did.

Applied sequentially at 15- to 30-second intervals, 8 mg of the NaOCl/liter and 2 mg of ClO_2/liter destroyed more bacteria in two minutes than corresponding single-stage disinfection data predicted. This effect may have been brought about by an interaction between the two disinfectants.

ξ ζ

Tyrrell, D. A. J. (1977). *Some Health Hazards Associated with Agricultural Improvements.* **PROC R SOC LOND, 199(1134)**:33-5.

The hazards of transmitting viruses and other pathogens in crops irrigated with feces are discussed.

θ δ

Vilím, V., Pešek, J., Brejcha, O., Žáková, M., Jindra, J., Průchová, M. (1977). *Viral Hepatitis A—Water Epidemic in a Bungalow Community.* **CESK EPIDEMIOL MIKROBIOL IMUNOL, 26(1)**:46-51. **Czechoslovakian.**

In August and September 1975, 24 adults and children became ill with hepatitis A in a recreational community in Cernovice. A total of 180 people resided in the community. All of the patients were negative for HBsAg.

The index case appeared to be a child who during the incubation period resided in a bungalow from which sewage penetrated into a well. A tracer experiment with NaCl indicated waterborne transmission from the well. Closure of the well terminated the epidemic.

μ

Walter, R., Rüdiger, S. (1977). *Studies on the Occurrence of Viruses in Ground Water.* **Z GESAMTE HYG, 23(7)**:461-3. **German.**

Eight of 62 samples collected between August 1974 and February 1975 from a ground water source for a large water supply system contained viruses. Fourteen MPNCU of viruses were recovered from 10 liters of one of the samples of water. Echoviruses 3, 6, and 30, coxsackieviruses B1, B4, and B5, and several unidentified viruses were recovered. Viruses were also recovered from surface water samples.

Viruses were concentrated from 10-liter samples of water by flocculation with $Al_2(SO_4)_3$ and recovered in FL cells.

ρ λ γ

Ward, R. L. *Inactivation of Enteric Viruses in Wastewater Sludge.* **In "Sludge Management Disposal and Utilization," Proceedings of the Third National Conference on Sludge Management Disposal and Utilization. Information Transfer Inc., Rockville, Maryland** (1977), 138-41.

Large numbers of poliovirus 1 were mixed with raw sludge for 15 minutes and subsequently recovered by sonication of the sludge in sodium dodecyl sulfate. The efficiency of recovery was 100%.

Ammonia (NH_3) appeared to be the only important agent in raw or digested sludges that inactivated poliovirus 1 at pH levels between 4.5 and 9.5. Poliovirus 2, coxsackieviruses A13 and B1, and echovirus 11 were also inactivated quickly by NH_3. In 0.5 M NH_4Cl solution (pH 9.5), >99.9999% of these viruses were inactivated at 21 C in 24 hours. Only 97% of reovirus 1 was inactivated under similar conditions.

NH_4^+ was not virucidal.

Digested sludge contained ammonia (NH_3 + NH_4^+) at a 0.055 M concentration. The pH of raw sludge was about 6. The pH of anaerobically digested sludge was about 9.

At pH 7, more than 99% of ammonia exists as NH_4^+. At pH 8, 5% occurs as NH_3, at pH 9, 41% is NH_3, and at pH 10, 87% is NH_3.

Elevating the pH levels of sludges may significantly reduce the virus populations in those sludges.

ρ γ

Ward, R. L. (1977). *Inactivation of Poliovirus in Wastewater Sludge with Radiation and Thermoradiation.* **APPL ENVIRON MICROBIOL, 33(5)**: 1218-9.

Sludge protected poliovirus 1 (CHAT) against heat and against ionizing radiation. The heat-sparing protection of the sludge increased with increasing solids concentration to a threshold solids level of a little under 1%.

Applied simultaneously, heat and gamma radiation destroyed the poliovirus more rapidly than the same exposure to heat and radiation separately.

ρ γ

Ward, R. L., Ashley, C. S. (1977). *Discovery of an Agent in Wastewater Sludge That Reduces the Heat Required to Inactivate Reovirus.* **APPL ENVIRON MICROBIOL, 34(6)**:681-8.

A natural component in raw and in anaerobically digested sludges increased the rate at which reovirus 3 (Dearing) was destroyed by heat. This component was associated with sludge solids, but could be washed from these solids with water.

The activity of the sludge component was greater in alkaline solutions than in acid solutions, probably because it was insoluble at low pH. The component was nonvolatile and heat-stable at 300 C, but it was inactivated within 30 minutes at 400 C. The rate of inactivation of the reovirus by heat in the presence of the sludge component was rapid, even at 35 C.

The sludge component did not affect inactivation of poliovirus 1 (CHAT) by heat.

ρ γ
Ward, R. L., Ashley, C. S. (1977). *Identification of the Virucidal Agent in Wastewater Sludge.* **APPL ENVIRON MICROBIOL, 33(4)**:860-4.

The NH_3 in anaerobically digested sludge irreversibly inactivates polioviruses and other picornaviruses. Reoviruses are resistant to NH_3.

Because NH_3 is not virucidal in its charged state, it has little activity at pH values lower than eight. Increasing the pH of sludge, therefore, should bring about rapid inactivation of indigenous picornaviruses.

ρ γ
Ward, R. L., Ashley, C. S. (1977). *Inactivation of Enteric Viruses in Wastewater Sludge Through Dewatering by Evaporation.* **APPL ENVIRON MICROBIOL, 34(5)**:564-70.

The infectivity of poliovirus 1 (CHAT) seeded into sludge gradually decreased with loss of water from the sludge until the solids content reached about 65%. With an increase in the solids content from 65% to 83%, a decrease in virus numbers of more than three orders of magnitude occurred. This loss of infectivity was irreversible because viral particles released RNA. The RNA was extensively degraded.

Viral inactivation may have been brought about by the evaporation process itself. Similar effects on poliovirus particles occurred in distilled water after loss of some water by evaporation.

Coxsackievirus B1 and reovirus 3 were also inactivated in sludge under evaporation.

Dewatering by evaporation may be a feasible method for inactivating enteric viruses in sludge.

γ
Young, D. C., Johnson, J. D., Sharp, D. G. (1977). *The Complex Reaction Kinetics of ECHO-1 Virus with Chlorine in Water.* **PROC SOC EXPER BIOL MED, 156(3)**:496-9.

A small fraction of the virions in a monodispersed suspension of echovirus 1 (Farouk) was briefly more resistant than the remainder of the virions to hypochlorous acid (HOCl). This resistant fraction was genetically homogeneous with the total population.

The resistant virions may possess a capsid conformation different from that of the capsids of most of the virion population, a conformation that may slow the penetration of the HOCl into the capsid.

γ
Young, D. C., Sharp, D. G. (1977). *Poliovirus Aggregates and Their Survival in Water.* **APPL ENVIRON MICROBIOL, 33(1)**:168-77.

Inactivation of aggregated poliovirus 1 by bromine was characterized by a continuously decreasing reaction rate.

Polioviruses released from infected cells by alternate freezing and thawing in water without electrolytes were aggregated. The aggregates persisted even on 7,000-fold dilution in ion-free water. Virions released from infected cells into phosphate-buffered saline solution were well dispersed, but aggregated when sedimented in a salt-free sucrose gradient or when diluted as little as 10-fold in water. Dispersed virions diluted in water in one large step remained dispersed.

Aggregated virions diluted in one large step (7,000-fold) in distilled or in untreated lake water did not disperse. Aggregated virions did disperse in one

such large step dilution in phosphate-buffered saline or in clarified secondary sewage effluent. Dispersed virions aggregated at all dilutions in alum-treated, finished water from a city filter plant perhaps as a result of complex formation with insoluble material rather than by virion-virion aggregation.

A simple rate-zonal centrifugation procedure (with different concentrations of sucrose set in colored layers) is described for rendering a very dilute suspension of mixed virion aggregates into a three-part spectrum of sizes.

μ δ

Zdrazilek, J., Srámová, H., Hoffmanová, V. (1977). *Comparison of Poliovirus Detection in Sewage and Stool Samples; A Study in a Creche in the Third Week After Vaccination.* **INT J EPIDEMIOL, 6(2)**:169-72.

In the third week after the vaccination of children with live attenuated poliovirus 1 (March 1975) and after the same interval following vaccination with polioviruses 2 and 3 combined (May 1975), corresponding poliovirus types were detected in stool samples and in sewage. Sewage was sampled by the gauze pad technic. The study was done in a Prague crèche.

Polioviruses were detected in sewage when they were excreted by approximately 1% of persons in the sewer catchment area of the small community.

γ

Zotova, V. I., Doskina, T. V. (1977). *Effect of Ultrasonics on the Chlorination of Viruses in Tap Water.* **GIG SANIT, 0(9)**:99-100. **Russian.**

Coliphage f2 that had been sonicated were destroyed more rapidly by chlorine than phage of the same preparation that had not been sonicated. Sonication may have broken apart clumps of virions thereby fully exposing to the disinfectant virions that had been partially or fully protected before sonication.

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